Chapter C4: RUM Analysis

Introduction

This case study estimates the effects of improved fishing opportunities due to reduced impingement and entrainment (I&E) in the North Atlantic region. The case study focuses on Atlantic coastal marine fishing sites in Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. The study applies benefit-function transfer, using a fishing site choice model developed by Robert Hicks from the National Marine Fisheries Service (NMFS), Office of Science and Technology (Hicks et al., 1999).

Cooling Water Intake Structures (CWIS) withdrawing water from North Atlantic coastal waters impinge and entrain many of the species sought by recreational anglers. These species include winter flounder, tautog, Atlantic cod, striped bass, bluefish, scup, and other less prominent species. Some of these species (e.g., weakfish, flounder, striped bass) inhabit a wide range of coastal waters spanning several states (e.g., striped bass are found throughout the North Atlantic region).

Chapter Contents

The main assumption of this analysis is that, all else being equal, anglers will get greater satisfaction, and thus greater economic value, from sites with a higher catch rate. This benefit may occur in two ways: first, an angler may get greater enjoyment from a given fishing trip with higher catch rates, yielding a greater value per trip; second, anglers may take more fishing trips when catch rates are higher, resulting in greater overall value for fishing in the region.

The following sections describe the data used in the analysis and the analytic results. Chapter A11 provides a detailed description of the RUM methodology used in this analysis.

C4-1 Data Summary

The Hicks et al. (1999) analysis of improvements in recreational fishing opportunities in the New England and Mid-Atlantic region relies on a subset of the NMFS Marine Recreational Fishery Statistics Survey (MRFSS), combined with the 1994 Add-on MRFSS Economic Survey (NMFS, 2003b; QuanTech, 1998).[1] The model of recreational fishing behavior developed in the study relies on a subset of the survey respondents that includes only single-day trips to sites located along the Atlantic coast. As explained further below, values for single-day trips were used to value each day of a multi-day trip. This section provides a summary of anglers' characteristics who took one-day trips to fishing sites in the five North Atlantic states. This analysis is based a sample of 9,314 respondents to the MRFSS survey.

[1] For general discussion of the MRFSS, see Chapter A11 of the Regional Study Report or Marine Recreational Fisheries Statistics: Data User's Manual, http://www.st.nmfs.gov/st1/recreational/pubs/data_users/index.html (NMFS, 1999a).

C4-1.1 Summary of Anglers' Characteristics

a. Fishing modes and targeted species

Based on the data set used in developing the NMFS model, a majority of the interviewed anglers (62 percent) fish from either a private or a rental boat (see Table C4-1). Approximately 24 percent fish from the shore; the remaining 14 percent fish from a party or charter boat. In addition to the mode of fishing, the MRFSS contains information on the specific species targeted on the surveyed trip. The most popular species group, targeted by 56 percent of all anglers, is small game. The second most popular species group, targeted by 18 percent of all anglers, is bottom fish. Approximately 12 percent of all anglers did not target a particular species. Of the remaining anglers, 10, 2, and 1 percent target flatfish, other species, and big game, respectively.

Table C4-1: Species Group Choice by Mode of Fishing in the North Atlantic Region

Species	All Modes		Private/Rental Boat		Party/Charter Boat		Shore	
	Frequency	Percent	Frequency	Percent by Mode	Frequency	Percent by Mode	Frequency	Percent by Mode
Small game	5,246	56.32%	3,429	59.33%	478	37.67%	1,339	59.12%
Bottom fish	1,705	18.31%	975	16.87%	510	40.19%	220	9.71%
Flatfish	914	9.81%	738	12.77%	10	0.79%	166	7.33%
Big game	116	1.25%	55	0.95%	53	4.18%	8	0.35%
No target	1,136	12.20%	541	9.36%	218	17.18%	377	16.64%
Other	197	2.12%	42	0.73%	0	0.00%	155	6.84%
All species	9,314	100.00%	5,780	62.00%	1,269	14.00%	2,265	24.00%

Source: NMFS, 2003b.

The distribution of target species is not uniform by fishing mode. For example, more than 76 percent of the anglers fishing from private/rental boats target either small game fish (59 percent) or bottom fish (17 percent). The majority of the anglers fishing from shore, on the other hand, target small game fish (59 percent) or do not have a targeted species (17 percent). Small game and bottom fish remain the most popular species groups among anglers fishing from a charter/party boat (38 and 40 percent, respectively).[2] A relatively large percentage of charter boat anglers target big game species (4 percent), compared to a small percentage of anglers targeting big game species from either private or rental boats (1 percent) or shore (0.35 percent).

b. Anglers' characteristics

This section presents a summary of angler characteristics for the North Atlantic region as defined above. Table C4-2 summarizes characteristics of the sample anglers fishing the NMFS sites in the North Atlantic region.

[2] Note that bottom species targeted by offshore anglers and charter boat anglers are different. Charter boat anglers usually target tautog, black sea basses, and drums, while offshore anglers target white perch, catfish, and dogfish sharks.

Table C4-2: Data Summary for the North Atlantic Coast Anglers

Variable	All Modes			Private/Rental Boat			Party/Charter Boat			Shore		
	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev	N	Mean[a]	Std Dev
Trip Cost	8,165	38.12	59.92	5,182	$33.36	$51.54	1,050	$72.34	$92.11	1,933	$32.30	$52.08
Travel Time	8,689	2.55	3.13	5,501	2.24	2.68	1,129	4.64	4.32	2,059	2.23	3.03
Visits	1,446	6.15	8.97	934	6.38	8.72	135	2.07	5.47	377	7.05	10.17
Own a Boat	1,880	0.55	0.50	1,104	0.75	0.43	298	0.19	0.39	478	0.29	0.45
High School	1,858	0.41	0.49	1,093	0.41	0.49	293	0.37	0.48	472	0.43	0.50
College Degree	1,858	0.18	0.39	1,093	0.20	0.40	293	0.19	0.39	472	0.15	0.36
Retired	1,873	0.15	0.35	1,100	0.13	0.34	296	0.14	0.34	477	0.19	0.39
Employed	1,873	0.79	0.41	1,100	0.82	0.38	296	0.79	0.41	477	0.71	0.45
Age	1,859	43.31	13.95	1,092	43.74	12.97	294	41.38	14.60	473	43.50	15.56
Years Fishing	1,914	20.72	15.30	1,131	21.19	14.62	303	17.98	15.93	480	21.34	16.25
Household Size	1,864	3.03	1.34	1,097	3.01	1.31	294	3.16	1.33	473	2.98	1.40
Flexible Time	1,456	0.69	0.46	892	0.69	0.46	230	0.70	0.46	334	0.68	0.47
Male	1,880	0.94	0.25	1,104	0.94	0.23	298	0.90	0.30	478	0.94	0.24
White	1,844	0.95	0.22	1,083	0.96	0.20	290	0.93	0.25	471	0.93	0.26
Household Income	1,667	$47,994	$29,233	990	$51,129	$29,229	265	$51,047	$29,554	412	$38,501	$26,967
Average Trip Length in Hours	8,676	3.95	2.12	5,499	4.22	2.13	1,128	4.65	1.96	2,049	2.84	1.73
Annual Trips	9,254	31.46	43.93	5,741	31.63	40.13	1,263	9.53	24.36	2,250	43.33	55.55

[a] For dummy variables, such as "Own a Boat," that take the value of 0 or 1, the reported value represents a portion of the survey respondents possessing the relevant characteristic. For example, 55 percent of the surveyed anglers own a boat.

Source: NMFS, 2003b; and U.S. Census Bureau, 2002.

The average income of respondent anglers was $47,994 (1994$).[3,4] Ninety-five percent of the anglers are white, with an average age of about 43 years. Educational attainment information indicates that 41 percent of the anglers had received a high school diploma, while only 18 percent had graduated from college. The average household size was three individuals.

Nearly 15 percent of the anglers are retired, while 79 percent are employed. Sixty-nine percent of the anglers indicated that they had flexible time when setting their work schedule.

Table C4-2 shows that on average anglers spent 31 days fishing during the past year. The average duration of a fishing trip was about 4 hours per day. Anglers made an average of 6.2 trips to the current site, with an average trip cost of $38.12 (1994$).[5] Average round trip travel time was about two and a half hours. Fifty-five percent of the North Atlantic anglers own their own boat. Finally, the average number of years of fishing experience was 21. This analysis does not include anglers under the age of 16, which may result in overestimation of the average age of recreational anglers and years of experience.

C4-1.2 Recreational Fishing Choice Sets

For consistency with Hicks et al. (1999), the Agency aggregated NMFS intercept sites (see Figure C1-1 in Chapter C1 for the survey intercept sites included in the analysis) to the county level, resulting in 26 sites from Maine through Connecticut. The 26 fishing sites, along with the angler's state of residence, define the individual's choice set. The choice set is defined according to the approach developed by Hicks et al. (1999). If the closest site is within 30 miles from the angler's home, then all sites within 150 miles are assumed to be in their choice set; otherwise, all sites within 400 miles are assumed to be in their choice set. Distances in the original study were estimated using PCMiler software. EPA used ArcView 3.2a software to determine the distance from an angler's residence to each NMFS intercept site. Further discussion of distance estimation is presented in section C4-1.4. Based on this method of site choice construction, EPA found that anglers in the five North Atlantic states have from 4 to 26 fishing sites in their choice sets.

C4-1.3 Site Attributes

This analysis assumes that the angler chooses between site alternatives by comparing his utility for each alternative and choosing the one that maximizes his utility. Following Hicks et al. (1999), this assumption states that the individual first chooses fishing mode and target species and then, conditional on this choice, chooses the recreational site.

Catch rate is the most important attribute of a fishing site from the angler's perspective (McConnell and Strand, 1994; Haab et al., 2000). This attribute is also a policy variable of concern as catch rate is a function of fish abundance, which is affected by fish mortality due to I&E. The catch rate variable in the model provides a means to measure baseline losses from I&E and changes in anglers' welfare attributed to changes from I&E due to the final section 316(b) rule.

To specify the baseline fishing quality of the case study sites, EPA followed the approach used by Hicks et al. (1999). The Agency calculated average historic catch rates based on the NMFS intercept survey data from 1990 to 1994 for recreationally important species, such as striped bass, bluefish, summer flounder, Atlantic cod, tautog, and winter flounder (McConnell and Strand, 1994; Hicks et al., 1999). EPA aggregated all species into five species groups — big game fish, bottom fish, flatfish, small game fish, and no-target — and calculated the average group-specific historic catch rates. Following the species groups definitions in Hicks et al. (1999), the following species are included in the four specific groups listed below. The "No-target" category covers all species caught by anglers that are not included in big game, bottom fish, small game fish, or flatfish.

- ***Big game:*** albacore, blue shark, bluefin tuna, shortfin mako shark, tuna, smooth hammerhead, thresher shark, billfish, cobia, great hammerhead, tiger shark, scalloped hammer, sailfish, wahoo, marlin, swordfish, white shark, tarpon, and dolphin.

[3] Income was not reported by most survey respondents. Median household income data by zip code, from the U.S. Census Bureau, was used to provide income information for respondents not reporting income.

[4] All costs are in 1994$, which represent the MRFSS survey year. All costs/benefits will be updated to 2002$ later in this analysis (e.g., for welfare estimation).

[5] All costs are in 1994$, which represent the MRFSS survey year. All costs/benefits will be updated to 2002$ later in this analysis (e.g., for welfare estimation).

- ***Bottom fish:*** Atlantic cod, Atlantic wolffish, black sea basses, blue angelfish, butterfish, codfishes, cunner, dwarf sand perch, gray triggerfish, haddock, perch family, pollock, porgies, reef bass, scup, skate, snapper, snowy grouper, spiny dogfish shark, striped searobin, tautog, white perch, sandbar shark, sand tiger shark, catfish, kingfish, black drum, dogfish shark, smooth dog shark, toadfish, hake, sawfish, mullett, nurse shark, sheepshead, cat shark, carp, grunt, and pinfish.

- ***Flatfish:*** Atlantic halibut, killifishes, flounders, mummichog, windowpane, and sole.

- ***Small game:*** Atlantic bonito, mackerels, Atlantic salmon, bluefish, brown trout, cero, hickory shad, little tunny, striped bass, weakfish, pompano, barracuda, snook, jack, bonefish, and red drum.

The species listed above inhabit waters from Maine through Virginia, the region covered in the Hicks et al. (1999) study. Not all of the listed species are present in the North Atlantic region, which includes only Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. The catch rates represent the number of fish caught on a fishing trip per angler by aggregated species group. The estimated catch rates are averaged across all anglers by wave, mode, target species group, and site over the five-year period (1990-1994).[6] Catch rates for earlier years were not included in the analysis due to significant changes in species populations for recreational fisheries.

The catch rate variables include total catch, which includes both fish caught and kept and fish released. Several NMFS studies use only the catch-and-keep measure as the relevant catch rate. Although a greater error may be associated with the measured number of fish not kept, the total catch measure is more appropriate because a large number of anglers catch and release fish. As noted above, EPA followed Hicks et al. (1999) in estimating the total catch rate variable. The total catch rate variable includes only targeted fish catch and not incidental catch. For example, flatfish catch rates include flatfish caught only by anglers targeting flatfish and do not include flatfish caught by anglers targeting another species group (e.g., small game). If an angler targeted a species group and caught no fish or caught fish of another species group, their catch rate was set to zero. Aggregated sites for which no historic catch rate was available were assigned an average historic catch rate of zero.

Anglers who target particular species groups generally catch more fish in the targeted category because of specialized equipment and skills than anglers who don't target these species. Of the anglers who target particular species groups, bottom fish anglers catch the largest number of fish per hour (1.28), followed by anglers who catch small game (0.65). Anglers who target big game fish catch fewer fish than anglers targeting any other species group. Table C4-3 summarizes average catch rates by species for all sites in the study area.

Table C4-3: Average Catch Rate by Species Group for the North Atlantic Region Sites[a]

Species Group	Average Catch Rate (fish per angler per trip)
Big Game	0.07
Bottom Fish	1.28
Flatfish	0.24
Small Game	0.65
No Target	0.35

[a] This includes aggregated sites (counties) in Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut.

Source: NMFS, 2002e.

[6] "Wave" is a two month period (e.g., May-June). Fishing conditions such as catch rates may differ significantly across six waves.

C4-1.4 Travel Cost

EPA used ArcView 3.2a software to estimate distances from the household zip code to each NMFS fishing site in the individual opportunity sets. The Agency obtained fishing site locations from the Master Site Register supplied by the NMFS. The Master Site Register includes both a unique identifier that corresponds to the visited site used in the angler survey, and latitude and longitude coordinates. For some sites, the latitude and longitude coordinates were missing or demonstrably incorrect, in which case the town point, as identified in the U.S. Geological Survey (USGS) Geographic Names Information System, was used as the site location if a town was reported in the site address. The Arc View program measured the distance in miles of the shortest route, using state and U.S. highways, from the household zip code to each fishing site, then added the distances from the zip code location to the closest highway and from the site location to the closest highway. The average one-way distance to the visited site is 58.6 miles.

Based on the procedure described in Hicks et al. (1999), EPA estimated trip "price" as the sum of travel costs plus the opportunity cost of time. To estimate consumers' travel costs, EPA multiplied round trip distance by average motor vehicle cost per mile ($0.30, 1994$).[7] To estimate the opportunity cost of travel time, EPA first divided round trip distance by 40 miles per hour to estimate trip time, and used the household's wage to yield the opportunity cost of time. EPA estimated household wage by dividing household income by 2,040.[8]

Only those respondents who reported that they can work extra hours for extra pay (*FLEXHR*=1) are assigned a time cost in the trip cost variable. Otherwise, the trip cost variable was calculated based on the round trip distance and the reimbursement rate of $0.30 per mile. EPA calculated visit price as:

$$Visit\ Price = \begin{cases} Round\ Trip\ Distance \times \$.30 + \dfrac{Round\ Trip\ Distance}{40\ mph} \times (Wage) & If\ FLEXHR = 1 \\ Round\ Trip\ Distance \times \$.30 & If\ FLEXHR = 0 \end{cases} \quad \text{(C4-1)}$$

For those respondents who cannot work extra hours for extra pay, the time cost is accounted for in an additional variable equal to the amount of time spent on travel. EPA therefore estimated time cost as the round trip distance divided by 40 mph:

$$Travel\ Time = \begin{cases} Round\ Trip\ Distance/40 & If\ FLEXHR = 0 \\ 0 & If\ FLEXHR = 1 \end{cases} \quad \text{(C4-2)}$$

C4-2 The Nested Random Utility Model of Recreational Demand

For the purpose of this analysis, EPA did not estimate its own random utility model (RUM) and relied on the study completed by Hicks et al. (1999) from the NMFS Office of Science and Technology (Volume II: The Economic Value of New England and Mid-Atlantic Sportfishing in 1994). Based on the Hicks et al. (1999) approach, each angler selects a fishing mode and target species first and, given this choice, selects the fishing site. Chapter 3 of the NMFS study describes the model in detail. The Hicks et al. (1999) model includes 10 variables: travel cost, travel time, five variables for catch rates (one for each species group), the log of the number of NMFS intercept sites contained in an aggregated site, a private/rental dummy, and a cold-private/rental dummy. The private/rental dummy equals 1 if the angler chose the private/rental fishing mode and owns their own boat and 0 otherwise. The cold-private/rental dummy equals 1 if the private/rental dummy equals one and the angler took his/her fishing trip in November or December (i.e., during cold months).[9] The model estimates are shown in Table C4-4.

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[7] The Federal Travel Regulations set the reimbursement rate at $0.29 per mile in 1994. This estimate includes vehicle operating cost only. This value per mile was taken from Hicks et. al., 1999.

[8] Based on Hicks assumption (Hicks et. al., 1999).

[9] Data are not collected for January and February in the North Atlantic region due to cold weather and, as a result, very low participation in recreational fishing.

Table C4-4: Estimated Coefficients for the Conditional Site Choice

Variable	Mean of the Variable	Estimated Coefficient (t-statistic)
Travel Cost ($)	61.84	-0.036 (-10.46)
Travel Time (hours)	3.69	-1.141 (-16.12)
Log of Number of NMFS Interview Sites in Aggregated Sites	3.11	1.247 (33.99)
Big Game Fish Catch	0.003	0.974 (2.69)
Small Game Fish Catch	0.39	0.579 (8.68)
Bottom Fish Catch	0.19	0.572 (100.68)
Flatfish Catch	0.26	0.665 (58.23)
No-target Catch	0.20	0.324 (15.23)
Mode/Species Choice Model		
Inclusive Value	4.90	0.612 (19.99)
Private/Rental Dummy	0.15	2.490 (42.02)
Cold Private/Rental Dummy	0.20	-0.553 (-4.08)

Source: U.S. EPA analysis for this report.

Table C4-4 shows that the coefficients have the expected signs. Travel cost and travel time have a negative effect on the probability of selecting a site, indicating that anglers prefer to visit sites closer to their homes (other things being equal). A positive sign on the private/rental dummy indicates that anglers who own a boat are more likely to go fishing. The probability of a site visit increases as the historic catch rate for fish species increases. The positive signs on the catch rate variables verify this assumption. The cold private/rental dummy has a negative sign suggesting that cold months (November and December) negatively affect the probability of site selection for boat anglers (i.e., boat anglers are less likely to visit a site during cold weather, all else being equal).

C4-3 Trip Frequency Model

EPA also examined effects of changes in fishing circumstances on an individual's choice concerning the number of trips to take during a recreation season. EPA used the negative binomial form of the Poisson regression model to estimate the number of fishing trips per recreational season. The participation model relies on socio-economic data and estimates of individual utility (the inclusive value) derived from the site choice model (Parsons et al., 1999; Feather et al., 1995). EPA estimated a combined participation model for the North Atlantic and Mid-Atlantic regions.[10] This section discusses results from the Poisson model of recreational fishing participation, including statistical and theoretical implications of the model. A detailed discussion of the Poisson model is presented in Chapter A11 of this report.

[10] EPA combined data for the North and Mid-Atlantic regions, as these regions are part of a single NMFS data set, to estimate the model. The Agency calculated separate estimates of participation and changes in participation for each region, based on average values of variables for that region.

The dependent variable, the number of recreational trips within the past 12 months, is an integer value ranging from 1 to 365. To avoid over-prediction of the number of fishing trips, EPA set the number of trips for anglers reporting over 125 trips per year to 125 in the model estimation.[11] The Agency first tested the data on the number of fishing trips for overdispersion to determine whether to use the Poisson model or the negative binomial model. If the dispersion parameter is equal to zero, then the Poisson model is appropriate; otherwise the negative binomial is more appropriate. The analysis found that the overdispersion parameter is significantly different from zero and therefore the negative binomial model is the most appropriate for this case study.

Independent variables of importance include gender, ethnicity, education, household size, hourly wage, whether the angler targets a species, whether the angler fishes from shore or from a boat, whether the angler is employed, whether the angler is self-employed, and whether the angler owns a boat. The model also includes a dummy variable to indicate whether the angler is from the North Atlantic region. Variable definitions for the trip participation model are:

- Constant: a constant term;
- IVBASE: the inclusive value estimated using the coefficients from the site choice model;
- HIGH_ED: equals 1 if the individual completed college or an advanced degree, 0 otherwise;
- HH_SIZE: household size;
- EMPLYED: equals 1 if the individual is employed; 0 otherwise;
- SELFEMP: equals 1 if the individual is self-employed; 0 otherwise;
- MALE: equals 1 if the individual is male; 0 if female;
- WHITE: equals 1 if the individual is white; 0 otherwise;
- OWNBT: equals 1 if individual owns a boat, 0 otherwise;
- NOTARG: equals 1 if the individual did not target a particular species; 0 otherwise;
- SHORE: equals 1 if the individual fished from shore; 0 if the individual fished from a boat;
- WAGE: household hourly wage (household income divided by 2,080);
- N_ATL: equals 1 if the individual is from the North Atlantic region; and
- α (alpha): overdispersion parameter estimated by the negative binomial model.

Table C4-5 presents the results of the trip participation model. Where a particular sign is expected, all estimated parameters have the expected signs. The model shows that the most significant determinants of the number of fishing trips taken by an angler are region (N_ATL), whether the angler fishes from shore (SHORE), whether the angler targets a species (NOTARG), boat ownership (OWNBT), whether the angler is male (MALE), whether the angler is employed (EMPLOYED), and the perceived quality of fishing sites (IVBASE).

The positive coefficient on the inclusive value index (IVBASE) indicates that the quality of recreational fishing sites has a positive effect on the number of fishing trips per recreational season. EPA therefore expects improvements in recreational fishing opportunities, such as an increase in fish abundance and catch rate, to result in an increase in the number fishing trips to the affected sites.

The model shows that anglers in the North Atlantic region take less fishing trips than those in the Mid-Atlantic region. Anglers who completed college or an advanced degree tend to take less fishing trips than those with less education. Anglers with larger households take fewer trips than those with smaller households, and those who are employed take fewer trips than those who are retired or otherwise not employed. However, self-employed anglers take more trips than those who are not self-employed. Male anglers fish more frequently than female anglers, and white anglers take more trips than non-white anglers. Anglers who own boats, those who target a specific species, those with higher incomes, and those who fish from shore take more trips each year.

[11] The number of trips was truncated at the 95th percentile, 125 trips per year.

Table C4-5: Trip Participation Model (Negative Binomial Model)

Variable	Coefficient	t-statistic
Constant	2.428	32.48
IVBASE	0.167	18.26
HIGH_ED	-0.146	-3.96
HH_SIZE	-0.033	-3.27
EMPLYD	-0.210	-5.84
SELFEMP	0.137	3.44
MALE	0.221	5.46
WHITE	0.124	2.64
OWNBT	0.379	11.78
NOTARG	-0.391	-11.43
SHORE	0.400	11.23
WAGE	0.003	2.40
N_ATL	-0.685	-18.29
α (alpha)	1.034	38.02

Source: U.S. EPA analysis for this report.

C4-4 Welfare Estimates

This section presents estimates of welfare losses to recreational anglers from fish mortality due to I&E, and potential welfare gains as a result of the final section 316(b) rule. These gains would result from improvements in fishing opportunities due to reduced fish mortality.

C4-4.1 Estimating Changes in the Quality of Fishing Sites

To estimate changes in the quality of fishing sites under different policy scenarios, EPA relied on the recreational fishery landings data by state and the estimates of recreational losses from I&E corresponding to different technology options. The NMFS provided recreational fishery landings data for the North Atlantic region states. EPA estimated the losses to recreational fisheries using the physical impacts of I&E on the relevant fish species, and the percentage of total fishery landings attributed to recreational fishing, as described in Chapter C2 of this document. I&E affects recreational species in two ways: by directly killing recreational species, and by killing forage species, thus indirectly affecting recreational species through the food chain. The indirect effects on recreational species were calculated in two steps. First, EPA estimated the total number of fish lost due to forage fish losses. Second, EPA allocated this total number of fish among recreational species according to each species' percent of total recreational landings.

The Agency measured changes in the quality of recreational fishing sites in terms of a percentage change applied to the historic catch rate. EPA assumed that catch rates will change uniformly across all marine fishing sites along the North Atlantic coast because species considered in this analysis (i.e., striped bass, bluefish, and flounder) inhabit a wide range of states (e.g., from North Carolina to Maine).[12] To estimate the expected change in catch rates, EPA used the most recent data

[12] Fish lost to I&E are most often very small fish, which are too small to catch. Because of the migratory nature of most affected species, by the time these fish have grown to catchable size, they may have traveled some distance from the facility where I&E occurs. Without collecting extensive data on migratory patterns of all affected fish, it is not possible to evaluate whether catch rates will change uniformly or in some other pattern. Thus, EPA assumed that catch rates will change uniformly across the entire region.

on total recreational landings in the North Atlantic region.[13] EPA used a five-year average of recreational landing data (1997 through 2001) for sites within state waters to calculate an average number of landings per year.[14] EPA then divided baseline losses to the recreational fishery from I&E by the total recreational landings to derive the percentage change in historic catch rates from completely eliminating I&E losses. EPA estimates the complete elimination of I&E losses to increase small game catch rates by 0.01 percent, bottom fish catch rates by 8.71 percent, flatfish catch rates by 16.11 percent, and no-target catch rates by 4.13 percent.

EPA also estimated percentage changes to species group historic catch rates resulting from reduced I&E losses resulting from the final section 316(b) rule. Dividing the reduced I&E losses by the 5-year average recreational landings leads to increases in the historic catch rates of 2.54 percent for bottom, 4.71 percent for flatfish, 1.21 percent for no-target, and 0.002 percent for small game. Table C4-6 presents the recreational landings, I&E loss estimates, and percentage changes in historic catch rates.

Table C4-6: Estimated Changes in Historic Catch Rates From Eliminating and Reducing I&E in the North Atlantic Region

Species Group	Total Recreational Landings for Five States Combined (fish per year)[a]	Baseline Losses		Reduced Losses Under the Final Section 316(b) Rule	
		Total Recreational Losses From I&E	Percent Increase in Recreational Catch From Elimination of I&E	Combined I&E	Percent Increase in Recreational Catch From Reduction of I&E
Small Game	13,713,213	1,155	0.01%	337	0.002%
Bottom Fish	6,106,054	532,078	8.71%	155,264	2.54%
Flatfish	2,377,698	383,164	16.11%	111,935	4.71%
No Target [b]	23,904,569	916,396	4.13%	267,536	1.21%

[a] Total recreational landings are calculated as a five-year average (1997-2001) for state waters.
[b] No target includes small game, bottom fish, and flatfish as well as other fish not included in those groupings. The other fish represent only a small number of impinged and entrained species and combined I&E for these other fish are 126 fish in the baseline and 16 fish under the final section 316(b) rule.

Source: NMFS, 2002e; and U.S. EPA analysis for this report.

C4-4.2 Estimating Losses from I&E in the North Atlantic Region

The recreational behavior model described in the preceding sections provides a means for estimating the economic effects of changes in recreational fishery losses from I&E in the North Atlantic region. First, EPA estimated welfare gain to recreational anglers from eliminating fishery losses due to I&E. This estimate represents economic damages to recreational anglers from I&E of recreational fish species under the baseline scenario. Then EPA estimated the gain in welfare from I&E reductions due to installation of the technology under the final section 316(b) rule. To estimate per-day welfare gain (loss), the Agency combined the Hicks' model coefficients with the estimated percentage changes in historic catch rates from eliminating or reducing I&E losses at the cooling water intake structures located in the North Atlantic Region, to get anglers' willingness-to-pay (WTP) for improvements in the quality of recreational fishing due to changes in I&E. Table C4-7 presents

[13] Note that the Agency followed Hicks et al. (1999) and used 1990-1994 data to characterize site-specific catch rates. The Agency used the most recent data on total recreational landings (1997-2001) to reflect the current conditions in estimating the expected change in total catch rate from changes in impingement and entrainment.

[14] State waters include sounds, inlets, tidal portions of rivers, bays, estuaries, and other areas of salt or brackish water; and ocean waters to three nautical miles offshore (NMFS, 2003b).

Table C4-7: Per-Day Welfare Gain from Eliminating and Reducing I&E in the North Atlantic Region (2002$)

Targeted Species	Baseline Per-Day Welfare Losses from I&E	Reduced Losses Under the Final Section 316(b) Rule (per-day welfare gain)	WTP for an Additional Fish Per Trip
Small Game	$0.002	$0.0001	$2.53
Bottom Fish	$0.19	$0.06	$1.06
Flatfish	$0.44	$0.13	$3.57
Big Game[a]	N/A	N/A	$5.90
No Target	$0.04	$0.01	$1.66

[a] Not estimated because of limitations of I&E data.

Source: U.S. EPA analysis for this report.

the compensating variation per day (averaged over all anglers in the sample) associated with reduced fish mortality from changes in I&E for each fish species of concern.[15,16]

The estimated per-day welfare gain resulting from eliminating all I&E at the cooling water intake structures is $0.44, $0.19, and $0.04 for flatfish, bottom fish, and no target, respectively (2002$). The estimated per-day welfare gain from reducing I&E at the cooling water intake structures under the final section 316(b) rule is $0.13, $0.06, and $0.01 for flatfish, bottom fish, and no target, respectively (2002$). As shown in Table C4-7, EPA expects flatfish anglers to experience the greatest welfare gain from reducing or eliminating I&E at the cooling water intake structures in the North Atlantic.

The results presented in Table C4-7 are not surprising. The more desirable the fish, the greater the per-day welfare gain as evidenced by the willingness-to-pay for catching one additional fish per trip. Of the species groups affected by I&E reductions, anglers value flatfish the most ($3.57 for an additional fish), followed by small game ($2.53). Anglers targeting big game, not surprisingly, place the highest value on catching an additional fish ($5.90). The estimated WTP for an additional fish per trip are consistent with those available from previous studies.

The Agency assumed that the welfare gain per day of fishing is independent of the fishing mode and the number of days fished per trip and therefore equivalent for all modes (i.e., private or rental boat, shore, and charter boat) for both single- and multiple-day trips. Each day of a multiple-day trip is valued the same as a single-day trip.[17] The model developed by Hicks et al. (1999) includes the fishing mode choice as well as the targeted species group choice. Thus, for every angler, regardless of mode or species choice, changes in historic catch rates for a particular species group offer a gain in welfare. Every fishing trip taken is the result of a choice decision affected by the changes in I&E. Therefore, all fishing trips taken should be included in estimating total losses from I&E.

EPA calculated total recreational losses to North Atlantic anglers by multiplying the estimated per-day welfare gain from eliminating I&E for a given species group by the total number of recreational fishing days in the North Atlantic. The total number of fishing days used in the analysis is the average of the those reported by NMFS and the predicted number of fishing trips estimated with the trip frequency model described in section C4-3. The total number of fishing trips reported by NMFS includes both single and multiple-day trips by state and fishing mode (Table C4-8). The Agency assumed that the welfare gain per day of fishing is independent of the number of days fished per trip and therefore equivalent for both single- and multiple-day trips. Each day of a multiple-day trip is valued the same as a single-day trip.

[15] A compensating variation equates the expected value of realized utility under the baseline and post-compliance conditions. For more detail, see the Proposed Section 316(b) Phase II Existing Facilities Rule Case Study Analysis.

[16] As the RUM model estimated values for single-day trips, the per-day value is equal to a per-trip value.

[17] See section C4-4.2 for limitations and uncertainties associated with ths assumption.

Table C4-8: Recreational Fishing Participation by Fishing Mode, Species Group, and State							
Private/Rental Boat							
State	**Big Game**	**Bottom Fish**	**Flatfish**	**Small Game**	**Other**	**No Target**	**Total**
CT	15,894	143,246	252,741	494,591	4,906	69,759	981,137
ME	6,886	62,061	109,500	214,282	2,125	30,223	425,078
MA	32,168	289,906	511,505	1,000,970	9,928	141,180	1,985,657
NH	1,881	16,954	29,913	58,537	581	8,256	116,122
RI	9,599	86,507	152,631	298,685	2,963	42,128	592,512
Subtotal	66,428	598,674	1,056,290	2,067,065	20,503	291,546	4,100,506
Party/Charter Boat							
CT	1,999	15,498	8,799	15,118	N/A	4,848	46,262
ME	85	657	373	641	N/A	206	1,961
MA	1,685	13,063	7,417	12,743	N/A	4,087	38,994
NH	667	5,173	2,937	5,046	N/A	1,618	15,441
RI	292	2,263	1,285	2,207	N/A	708	6,754
Subtotal	4,728	36,654	20,811	35,755	N/A	11,467	109,412
Shore							
CT	1,530	56,189	148,121	362,446	42,698	84,422	695,406
ME	1,032	37,894	99,893	244,432	28,795	56,934	468,980
MA	4,007	147,173	387,967	949,336	111,837	221,123	1,821,442
NH	219	8,061	21,251	52,000	6,126	12,112	99,770
RI	1,735	63,731	168,003	411,094	48,429	95,754	788,745
Subtotal	8,523	313,048	825,235	2,019,308	237,885	470,345	3,874,343
Total	79,679	948,376	1,902,336	4,122,128	258,388	773,358	8,084,261

Source: NMFS, 2002d.

The trip frequency model is utilized to account for anglers increasing the number of trips they take in response to an improvement in fishing conditions. The increased estimates are shown in Table C4-9 and are estimated for eliminating I&E and reduced losses under the final section 316(b) rule.

Table C4-9: Increased Recreational Fishing Participation				
Number of Fishing Days in 2001 Reported by NMFS	**Predicted Percent Change in Annual Fishing Trips**		**Increased Recreational Fishing Participation**	
	Baseline I&E	**Reduced I&E**	**Baseline I&E**	**Reduced I&E**
8,084,261	0.33%	0.10%	8,111,065	8,092,106

Sources: NMFS MRFSS Survey, 2003b; and U.S. EPA analysis for this report.

Table C4-10 summarizes the calculated total welfare gain to recreational anglers. These values were discounted to reflect the fact that fish must grow to a certain size before they will be caught by recreational anglers. EPA calculated discount factors separately for impingement and entrainment of each species. To estimate discounted total benefits, EPA calculated weighted averages of these discount factors, and applied them to estimated willingness-to-pay values. Discount factors were calculated for both a three percent discount rate and a seven percent discount rate. For the final section 316(b) rule, an additional discount factor was applied to account for the one-year lag between the date when installation costs are incurred and the installation of the required cooling water technology is completed.

Table C4-10: Estimated Total Welfare Gain to Recreational Anglers From Eliminating and Reducing I&E in the North Atlantic Region (2002$)

Species Group	Eliminating Recreational Fishery Losses From I&E			Reduced Losses Under the Final Section 316(b) Rule		
	Undiscounted	3% Discount Factor	7% Discount Factor	Undiscounted	3% Discount Factor	7% Discount Factor
Small Game	$13,223	$11,901	$10,447	$508	$444	$375
Bottom Fish	$1,563,511	$1,454,066	$1,328,985	$450,570	$406,824	$357,930
Flatfish	$3,534,229	$3,110,122	$2,686,014	$1,033,625	$883,094	$734,164
Big Game	N/A	N/A	N/A	N/A	N/A	N/A
No Target	$326,842	$297,426	$264,742	$101,728	$89,876	$77,009
All Species	$5,437,805	$4,873,515	$4,290,188	$1,586,431	$1,380,238	$1,169,478

Source: U.S. EPA analysis for this report.

The total value of recreational losses for all species impinged and entrained at the cooling water intake structures in the North Atlantic is $5.44 million per year (2002$), for all anglers, before discounting. The discounted recreational losses are $4.87 million and $4.29 million (2002$) per year, discounted at three and seven percent, respectively.

Total recreational losses based on reduced I&E from cooling water intake structures were also estimated. Multiplying the per-day welfare changes from reduced I&E under the final section 316(b) rule by the total number of fishing trips in 2001 yielded an undiscounted value of $1.59 million. Discounting the welfare gain by three and seven percent results in total welfare gains of $1.38 million and $1.17 million, respectively. For the final section 316(b) rule, an additional discount factor was applied to account for the one-year lag between the date when installation costs are incurred and installation of the required cooling water technology.

C4-5 Limitations and Uncertainties

C4-5.1 Considering Only Recreational Values

This study understates the total benefits of improvements in fishing site quality because estimates are limited to recreation benefits. Many other forms of benefits, such as habitat values for a variety of species (in addition to recreational fish), non-use values, etc., are also likely to be important.

C4-5.2 Extrapolating Single-Day Trip Results to Estimate Benefits from Multiple-Day Trips

Use of per-day welfare gain estimated for single-day trips to estimate per-day welfare gain associated with multiple-day trips can either understate or overstate benefits to anglers taking multiple-day trips. Inclusion of multi-day trips in the model of recreational anglers' behavior can be problematic because multi-day trips are frequently multi-activity trips. An individual might travel a substantial distance and participate in several recreational activities such as shopping and sightseeing, all as part of one trip. Recreational benefits from improved recreational opportunities for the primary activity are overstated if all travel costs are treated as though they apply to the one recreational activity of interest. EPA therefore limited the recreational behavior model to single-day trips only and then extrapolated single-day trip results to estimate benefits to anglers taking multiple-day trips.

There is evidence that multi-day trips are more valuable than single-day trips. McConnell and Strand (1994) estimated a RUM using the NMFS data for New England and the Mid-Atlantic. Their study was intended to supplement the RUM study of single-day trips for the same region conducted by Hicks et al. (1999). The reported values for a catch rate increase of one fish are consistently higher for overnight trips than for single-day trips. Lupi and Hoehn (1998) compared values for single- and multi-day fishing trips. Their comparison is based on a RUM for the Great Lakes, with single- and multiple-day trips treated as distinct alternatives in the choice set, with separate parameters for different length trips. They found that multiple-day trips are less responsive to changes in travel cost, and thus relatively more valuable than single-day trips. Their case study results found that "over half the value of an across the board marginal change in catch rates was due to multiple-day trips even though multiple-day trips represent less than one fourth of the trips in the sample" (p. 45).

C4-5.3 Potential Sources of Survey Bias

The survey results could suffer from bias, such as recall bias and sampling effects.

a. Recall bias

Recall bias can occur when respondents are asked, such as in the MRFSS, the number of their recreation days over the previous season. Some researchers believe that recall bias tends to lead to an overstatement of the number of recreation days, particularly by more avid participants. Avid participants tend to overstate the number of recreation days because they count days in a "typical" week and then multiply them by the number of weeks in the recreation season. They often neglect to consider days missed due to bad weather, illness, travel, or when fulfilling "atypical" obligations. Some studies also found that the more salient the activity, the more "optimistic" the respondent tends to be in estimating the number of recreation days. Individuals also have a tendency to overstate the number of days they participate in activities that they enjoy and value. Taken together, these sources of recall bias may result in an overstatement of the actual number of recreation days.

b. Sampling effects

Recreational demand studies frequently face observations that do not fit general recreation patterns, such as observations of avid participants. These participants can be problematic because they claim to participate in an activity an inordinate number of times. This reported level of activity is sometimes correct but often overstated, perhaps due to recall bias. Even where the reports are correct, these observations tend to be overly influential (Thomson, 1991).